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Experimental Study on Geopolymer Concrete with Partial Replacement of Fine Aggregate with Foundry Sand

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Abstract: **Cement is mostly utilized for construction in present time because of its need but side by side its drawbacks to environment also require attention. Also if we leave the waste materials to the environment directly, it can cause environmental problem. So this needs to be attention that this waste material should be utilized as possible. These waste materials can be used to produce new products and also this waste can be used as admixtures. So that our natural resources can be used more efficiently and we can save environment from waste deposits. By using geopolymer concrete we can protect global environment from impact of cement production. Davidovits [1988] explain that we can use some materials as a binder in concrete in place of cement. Materials such as rice husk ash and fly ash (both are by product material or waste materials) when mixed with alkaline liquid can produce a new material which have some properties like binding material like cement. Concrete resulting by polymerization process is known as geopolymer concrete. Main constituents of this concrete are source materials and the alkaline liquids. Source material may be waste by-products materials e.g. Silica fume, RHA, Red mud, Iron slag etc. Used-foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. In this study an experiment is made to found out the effectiveness of used foundry sand as a partial replacement of fine aggregate in geopolymer concrete. The percentage of replacement are 0%, 5%, 10%, 15%, 20% and 25% by weight of fine aggregate by waste foundry sand. In this study, 7 day and 28 day compressive strength, split tensile strength and flexural tensile strength of samples were found out.**

Keywords: **Alkaline Liquid, Binder, Ferrous metal, Foundry Sand, Geopolymer, Polymerization**

I. INTRODUCTION:

Now its present society challenge is to protection of environment. Now days, these topics are getting considerable attention under sustainable development. Big attention is being focused on the safe guarding of the environment and natural resources and recycling of wastes materials. Incorporate scraps are producing by number of significant products due to many industries. In the last 20 years, a lot of work related to the use of different types of urban wastes in construction materials has been published. Different waste materials are showing useful application in construction industry as substitute to conventional construction materials. Hence adoption of such waste materials in construction conserves natural resources and reduces the area of land required for disposal of these waste materials, which spoil land properties. This study gives idea regarding establishment of quality standards for recycled materials and wastes. This work would results in setting required product quality for producers. The study report stresses the importance of recycling waste and suggests a sustainable technique of conserving natural resources and management of waste, apart from evolving a green technology for concrete making.

These waste materials can be used to produce new products and also this waste can be used as admixtures. So that our natural resources can be used more efficiently and we can save environment from waste deposits. Davidovits [1988] explain that we can use some materials as a binder in concrete in place of cement. Materials such as rice husk ash and fly ash (both are by product material or waste materials) when mixed with alkaline liquid can produce a new material which have some properties like binding material like cement. Concrete resulting by polymerization process is known as geopolymer concrete. Source material may be waste by-products materials e.g. Silica fume, RHA, Red mud, Iron slag etc. We can choose source material according to availability, type of application, cost and specific demand. Geopolymers are like inorganic polymers. Geopolymer and zeolotic materials having the same chemical composition and amorphous microstructure instead of crystalline (Palomo 1999).

Hardjito(2004) studied about how to produce environmentally friendly construction materials .Geopolymer concrete produced to overcome effect of pollution to environment. So in low-calcium fly ash was chemically activated by a high-alkaline solution to form a paste that act like cement (binds the loose coarse and fine aggregates together. To evaluate the resistance of geopolymer concrete to sulphate attack, specimens were soaked in a 5% sodium sulphate (Na_2SO_4) solution for different periods of time. Kolli. Ramujee (2013)In this paper attempt is made to develop the mix design for geopolymer concrete in low, medium and higher grades and relative comparison has been made with equivalent mix proportions of grades of OPC Concretes in both heat cured and ambient cured conditions. The result showed that the Geopolymer Concrete design mix depends on various factors such as water/binder ratio and liquid/ fly ash ratio. The compressive strength of GPC can be achieved by decreasing water binder ratio. The compressive strength attained at 28 days for all grades of geopolymer concrete under ambient curing is almost equal to compressive strength achieved by geopolymer concrete at 7 days. Because of the slow reactivity of fly ash at ambient temperature, considerable heat must be applied to increase the geopolymerization process.

II. EXPERIMENTAL PROGRAMS:

Material used:

1) Ground Granulated Blast Furnace Slag:
Ground granulated blast furnace slag (GGBS) is a by-product from the blast-furnaces used to make iron. GGBS can be used to make durable concrete structures.

2) Silica Ash:
Rice husk is an agricultural residue abundantly available in rice producing countries. The annual rice husk production in India amounts about 12 million tons. Among the different types of biomass used for gasification, rice husk has a high ash content varying from 18 – 20 %. Silica is the major constituent of rice husk. So it can be effectively used for green concrete applications.

3) Alkaline Liquid:
A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. It is recommended that the NaOH solution should be made 24 hours before casting and should be used with 36 hours of mixing the pellets with water as after that it is converted to semi-solid state.

4) Fine Aggregate:
Fine aggregates used are less than 4.75 mm.

5) Coarse Aggregate:
Locally available coarse aggregate with maximum size of 10mm and 20 mm were used in this project.

6) Foundry Sand
Used-foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed used or spent foundry sand.

III. EXPERIMENTAL WORK

In this research the total no. of 108 specimens were casted and tested. The mould size was as per IS 10086-1959. For the purpose of this study, the mix design was chosen to be the one given by Kolli Ramuujie in his study. Silica ash and GGBS is used instead of cement along with alkaline solution, coarse aggregate, and fine aggregate. Curing is done at temperature (ambient curing 80°C). We have used black foundry sand or waste foundry sand as a replacement of the sand in the mix. The replacement is dineas 5%, 10%, 15%, 20%, 25%. The engineering properties of concrete were tested according to the Indian Standards. For testing the compressive strength of concrete, cubes of 150 mm X 150 mm X 150 mm dimensions were casted and tested. The compressive strength of concrete is measured at 7 and 28 days. Flexural Strength test was carried out by casting beams of size 100mm X 100mm X 500mm dimensions, testing was carried on 7, 28 days. Split tensile test was also carried out by casting cylinder of size 100 mm X 200mm and testing is done after 7, 28 days. IS: 516-1959 code specification is followed for testing the strength of concrete. This study aims at determining the effect on concrete strength due to replacement of sand by foundry sand.

MIX PROPORTION:

Silica ash based geopolymer concrete for M20							
Sr. No.	**Material**	**0% Replacement of Foundry Sand**	**05% Replacement of Foundry Sand**	**10% Replacement of Foundry Sand**	**15% Replacement of Foundry Sand**	**20% Replacement of Foundry Sand**	**25% Replacement of Foundry Sand**
1	Silica Ash + GGBS	394.3	394.3	394.3	394.3	394.3	394.3
2	Normal Sand	646.8	614.46	582.12	549.78	517.44	485.10
3	Foundry sand	000	32.34	64.68	97.02	129.36	161.7
5	Coarse aggt	1201.2	1201.2	1201.2	1201.2	1201.2	1201.2

6	NaOH	45.06	45.06	45.06	45.06	45.06	45.06
7	Na_2SiO_3	112.64	112.64	112.64	112.64	112.64	112.64
8	Morality	16	16	16	16	16	16
9	Ratio of mix. Prop.	1:1.64:3.04	1:1.64:3.04	1:1.64:3.04	1:1.64:3.04	1:1.64:3.04	1:1.64:3.04
10	Liquid/Binder	.40	.40	.40	.40	.40	.40

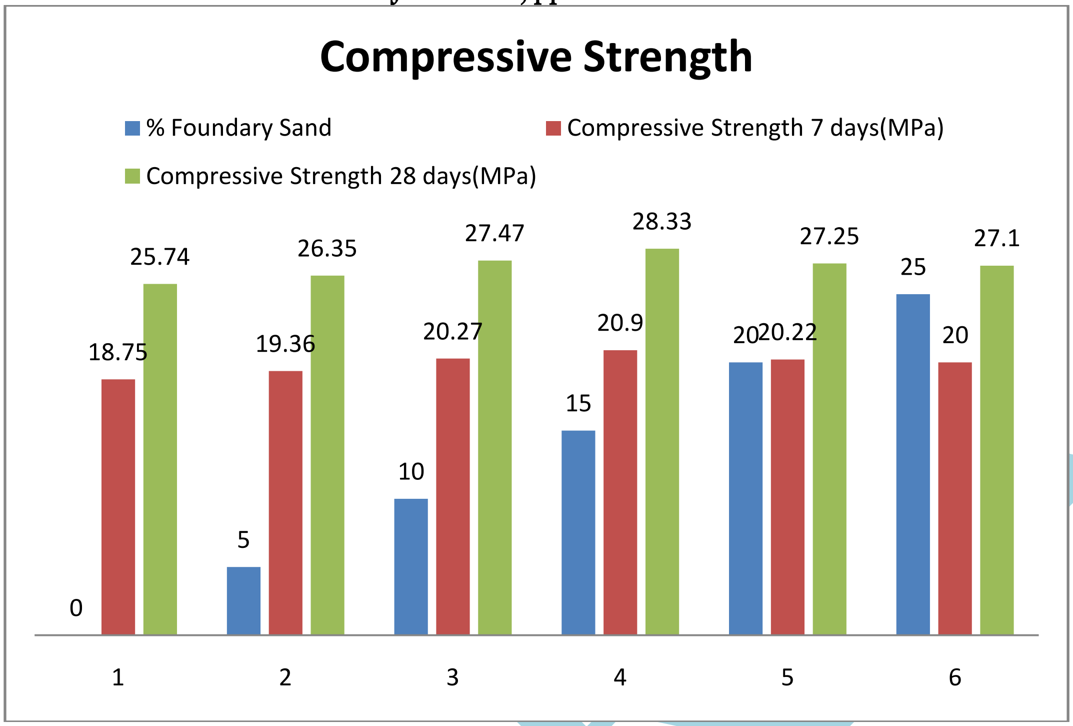
3. RESULT:

S.No.	**Percentage Replacement (Foundry sand)**	**Average Compressive Strength after 7Days(N/mm)**	**Average Compressive Strength after 28Days(N/mm^2)**	**Split Tensile Strength after 7 Days Curing(N/mm^2)**	**Split Tensile Strength after 28 Days Curing(N/mm^2)**	**Flexural Tensile Strength after 7 Days Curing(N/mm^2)**	**Flexural Tensile Strength after 28 Days Curing(N/mm^2)**
1	0%	18.75	25.74	2.12	3.71	4.2	5.20
2	5%	19.36	26.35	2.22	3.90	4.7	5.24
3	10%	20.27	27.47	2.92	4.23	5.0	5.83
4	15%	20.90	28.33	2.64	4.10	4.6	5.23
5	20%	20.22	27.25	2.10	3.95	4.1	4.80
6	25%	20.00	27.10	1.90	3.74	3.9	4.0

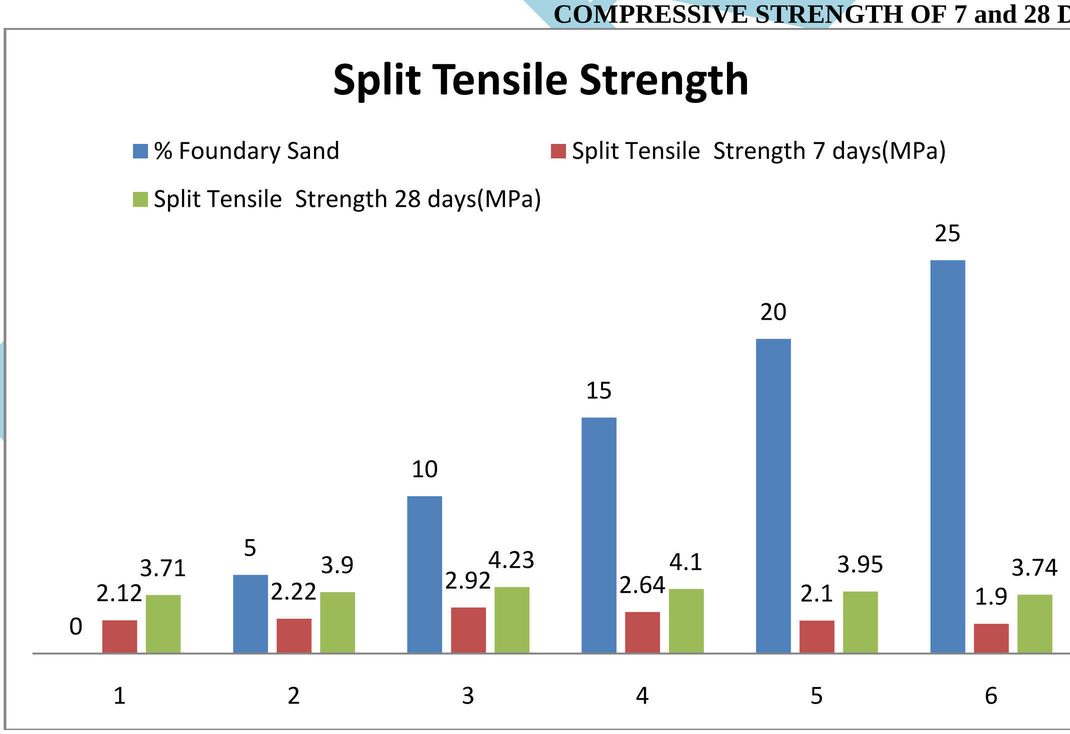
COMPRESSIVE STRENGTH:

a) The 7 day compressive strength of the sample obtained a maximum strength of 20.90 N/mm^2. The 7 day maximum strength was also obtained for 15% replacement of fine aggregate with foundry sand and there is 11.46% increase in strength.

b) The 28 day compressive strength of the sample obtained a maximum strength of 28.33N/mm^2. The 28 day compressive strength was also maximum for 15% replacement of fine aggregate with foundry sand and there is 10.06% increase in strength.



COMPRESSIVE STRENGTH OF 7 and 28 DAYS



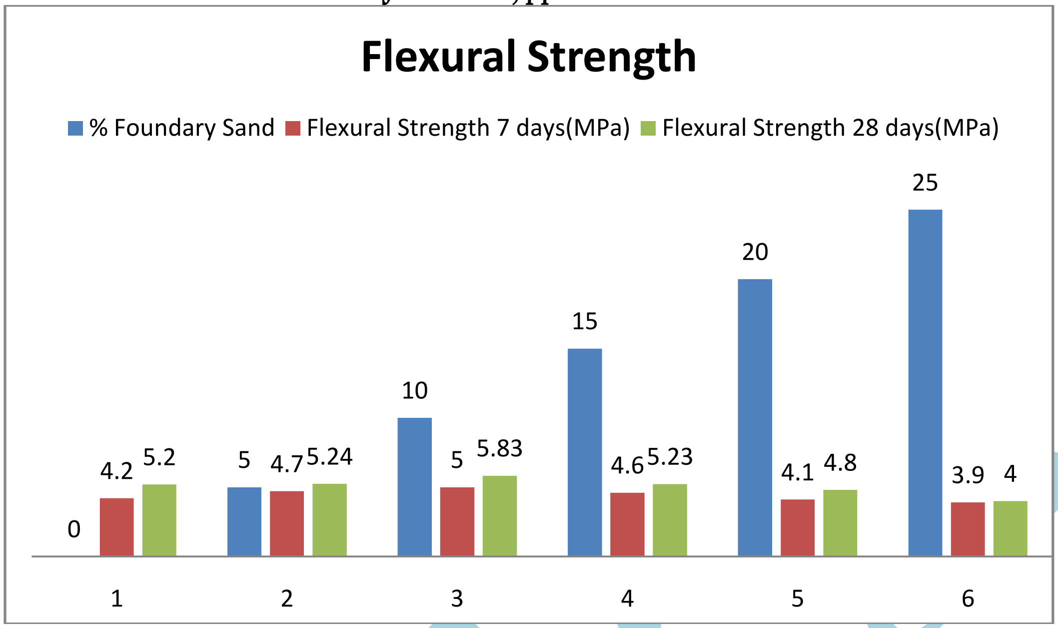
SPLIT TENSILE STRENGTH OF 7 and 28 DAYS

SPLIT TENSILE STRENGTH

a) The 7 day Split tensile strength of the sample obtained a maximum strength of 2.92 N/mm^2. The 7 day maximum strength was also obtained for 10% replacement of fine aggregate and there is 37.73% increase in strength.

b) The 28day Split tensile strength of the sample obtained a maximum strength of 4.23 N/mm^2. The 28 day maximum strength was also obtained for 10% replacement of fine aggregate and there is 14% increase in strength.

FLEXURAL STRENGTH:



a) The 7 day Flexural strength of the sample obtained a maximum strength of 5.0 N/mm^2. The 7 day maximum strength was also obtained for 10% replacement of fine aggregate and there is 19.04% increase in strength.

b) The 28 day Flexural strength of the sample obtained a maximum strength of 5.83 N/mm^2. The 28 day maximum strength was also obtained for 10% replacement of fine aggregate and there is 12.11% increase in strength.

IV. CONCLUSION:

Based on the results of the experimental investigation, following conclusions are drawn: -

a) The silica ash – GGBS based geopolymer concrete gained strength with earlier time period through oven curing at 80○ C.

b) The 7 days and 28 days maximum compressive strength was also obtained for 15% replacement of fine aggregate. Thus we found out the optimum percentage for replacement of foundry sand with natural sand is almost 15% for cubes.

c) The 7 days and 28 days maximum split tensile strength was also obtained for 10% replacement of fine aggregate. Thus we found out the optimum percentage for replacement of foundry sand with natural sand is almost 10% for cylinders.

d) The 7 days and 28 days Flexural strength was obtained for 10% replacement of fine aggregate. Thus we found out the optimum percentage for replacement of foundry sand with natural sand is almost 10% for cylinders.

e) We have put forth a simple step to minimize the costs for construction with usage of foundry sand which is freely or cheaply available; more importantly.

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